Technical Aspects of the Advanced Camera for Surveys Repair (ACS-R)

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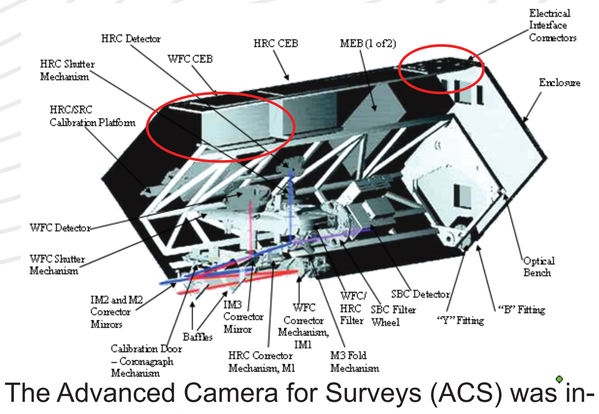
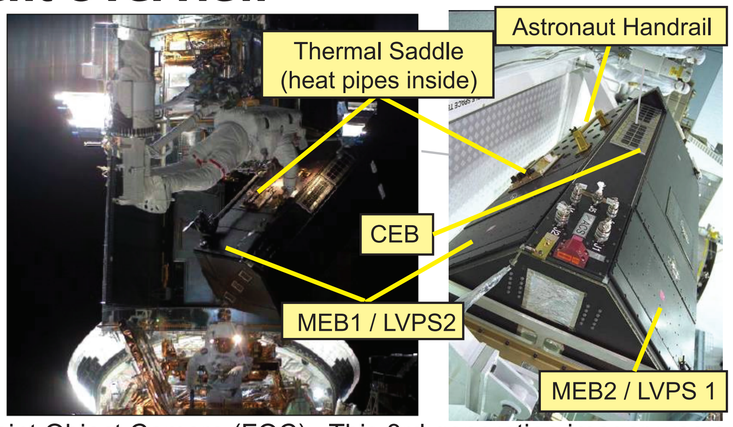
Abstract:
In January 2007, the Hubble Space Telescope (HST) Advanced Camera for Surveys (ACS) lost its Wide-Field Channel (WFC) and the High Resolution Channel (HRC) due to a failure in its Low Voltage Power Supply (LVPS). A team was rapidly assembled to determine if the ACS could be repaired as part of HST Servicing Mission 4 (SM4). This team includes contributors from NASA's Goddard Space Flight Center, Ball Aerospace, and Teledyne Imaging Sensors. It determined that all of the capabilities of the ACS could be restored and created a concept for the ACS-Repair (ACS-R) component of SM4. ACS-R will restore the WFC of ACS by replacing the existing CCD Electronics Box (CEB) with the CEB-Replacement (CEB-R) and providing power from a new Low Voltage Power Supply Replacement (LVPS-R). The new LVPS-R will also attempt to restore the HRC function by providing power through the original power bus. In this presentation, we focus on the concept and technical aspects of the ACS-R.

Instrument Overview

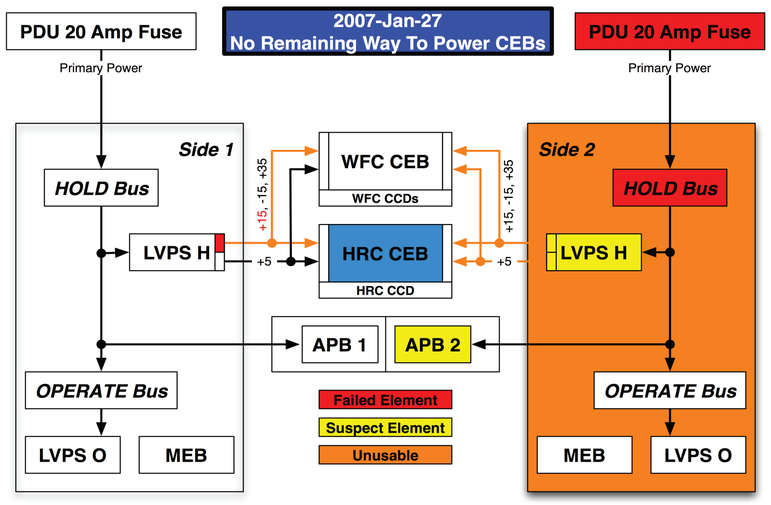


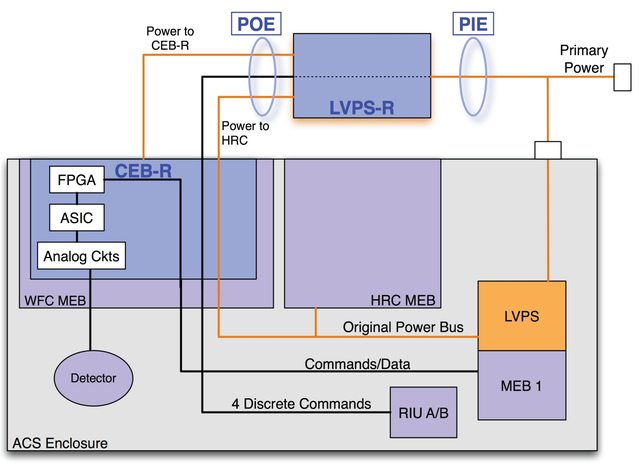


The Advanced Camera for Surveys (ACS) was installed during Servicing Mission 3B, replacing the Faint Object Camera (FOC). This 3rd generation imager was an HST workhorse until the 2007 anomaly. ACS included a Wide Field Channel (WFC), a High Resolution Channel (HRC), and a Solar Blind Channel (SBC). The first two of these were disabled by the electronics failure. A much more complete discussion of the scientific capabilities of ACS, particularly in light of the new capabilities added during Servicing Mission 4 (SM4), is presented in several accompanying posters.

The Anomalies

On June 19, 2006, ACS had an anomaly that left the Side-1 electronics for the WFC and HRC non-operational. The likely cause for this was either the failure of an interpoint converter on LVPS3, or a short to ground in LVPS3. On July 4, 2006, ACS was brought back online using the Side-2 electronics. On January 27, 2007, the electronics on Side-2 failed, probably due to a short in the Hold Bus. This leaves Side-2 completely inoperable. On February 15, 2007, ACS operation was resumed using the Side-1 electronics for the SBC only. The figure above shows the current state of ACS.





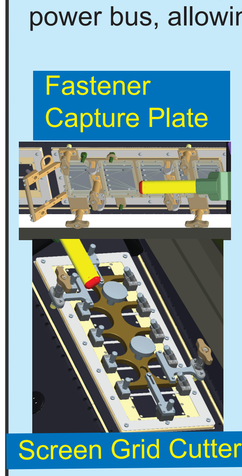
ACS-R Overview

ACS-R is designed to restore full, non-redundant operation to ACS by
1) Replacing the original WFC CEB boards with the CEB-R
2) Replacing the original LVPS with the LVPS-R

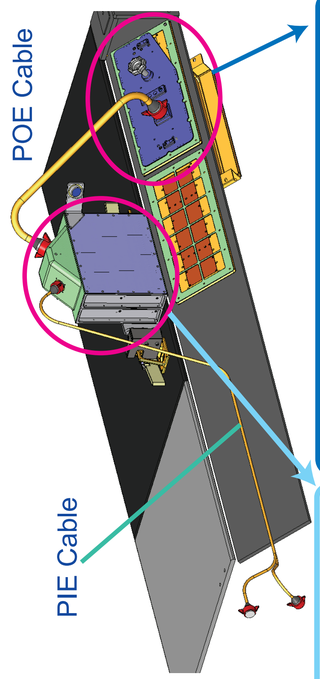
Power from the LVPS-R will allow operation of WFC on ACS by using the new CEB-R, and the HRC will be restored by powering the original HRC CEB through the WFC (backpowering). Some details of this are shown in the electrical schematic at left. The repair is designed so that failure of HRC backpowering does not pose risk to the success of the WFC repair.

ACS-R Elements

LVPS-R: The LVPS-R is mechanically mounted on the ACS via clamps to the ACS handrail. Once mechanically attached, power is provided to the LVPS-R from the ACS primary power connectors, using the PIE cable. The POE cable then provides power from the LVPS-R to the CEB-R. Power provided to the CEB-R will feed through to the original power bus, allowing backpowering of the ACS HRC.

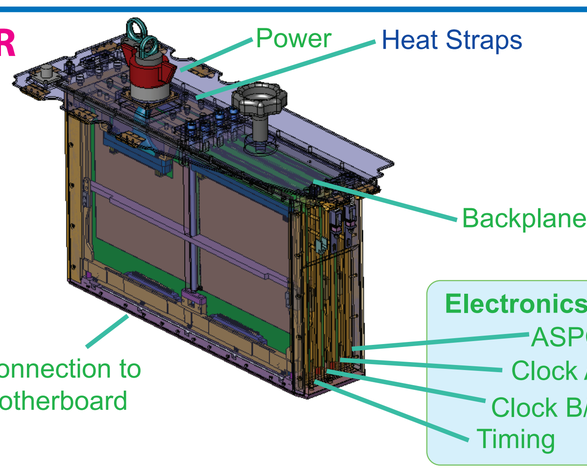


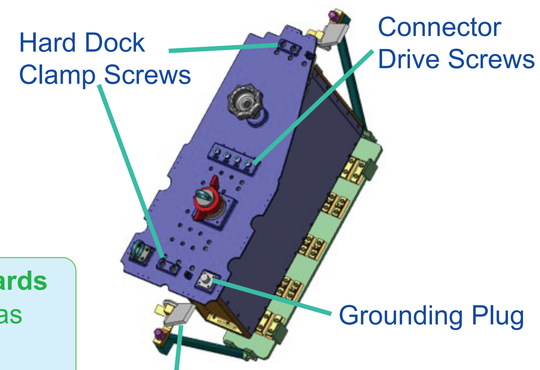
CEB-R: A new tool, the Screen Grid Cutter (SGC) will be used to remove the EMI grid over the WFC CEB. After removal, the astronauts will be able to access and remove the cover and top plates. This will require the use of a Fastener Capture Plate (FCP). The FCP allows removal of screws from ACS while providing a means of containment for the loose screws. Four Card Extraction Tools (CETs) will facilitate removal of the old CEB cards. The CEB-R can then be installed. The CEB-R is inserted into the WFC CEB, and the Hard Dock Clamps lock the module in place. The four Connector Drive Screws are then used to connect the four CEB-R boards to the WFC.

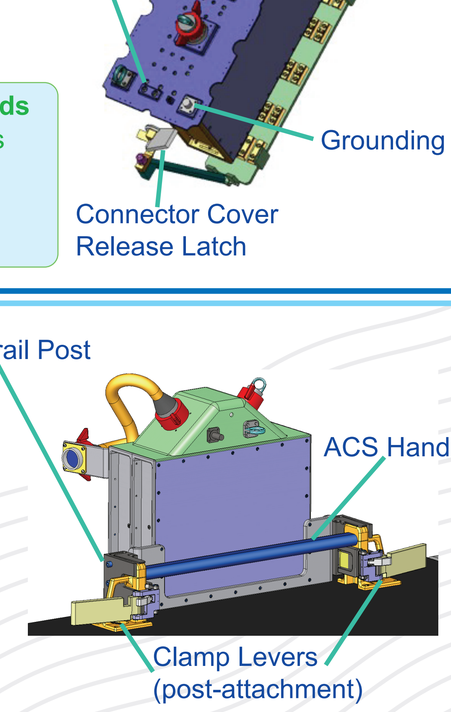


POE = Power Output Element, power to the CEB-R

PIE = Power Input Element, power from HST to LVPS-R and the ACS

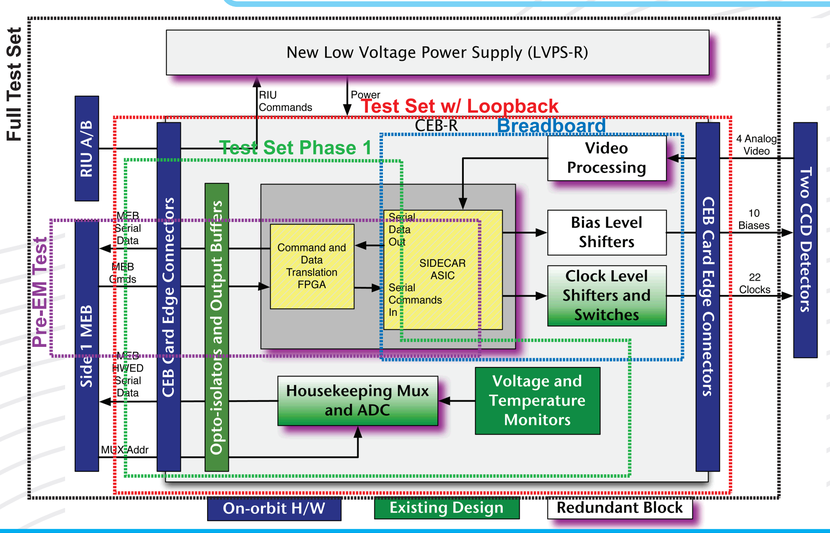






Testing

All components for ACS-R are being thoroughly tested prior to SM4. The bulk of this work is focused on the CEB-R, as this is the most complex element. The schematic at right shows the CEB; the boxes drawn with dashed lines indicate elements that will be tested as development continues. Breadboard tests (in blue) verified functionality and noise performance. Pre-EM testing (purple) will allow flight software testing and supports flight code development. The Phase 1 Test Set (blue) provides MEB interfaces, and frees the ACS Ops Bench for other uses. Addition of Loopback (red) allows verification of CCD drive signals. Finally, the complete Test Set (black) allows all functional testing, and can be used with actual detectors to verify performance. It also allows for testing of the LVPS-R. Four of these units will be built to allow maximum flexibility in development and testing.



A Projected EVA Timeline

Start Duration Task

- ACS Preparation
- Install Guide Studs
- Remove the EMI Grid
- Remove WFC Access Cover Plate and CEB Top Plate
- Remove 4 WFC CEB electronics boards
- Install WFC CEB Replacement module (CEB-R)
- Install Power Supply Module (LVPS-R) to ACS handrail
  - ➜ Mate PIE connector to LVPS-R
  - ➜ Mate POE conector to CEB-R
- ACS worksite clean-up

ACS-R is only possible through the efforts of a number of dedicated individuals and organizations, including Ball Aerospace (Mechanical Design and Fabrication), Jackson & Tull (Fab, Assembly, and Testing), Teledyne (ASIC design and testing), Goddard (system integration and testing, flight software), and others.